



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
02.11.2011 Bulletin 2011/44

(51) Int Cl.:
F25B 1/00 (2006.01)

(21) Application number: **09839146.9**

(86) International application number:
PCT/JP2009/051233

(22) Date of filing: **27.01.2009**

(87) International publication number:
WO 2010/086954 (05.08.2010 Gazette 2010/31)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR

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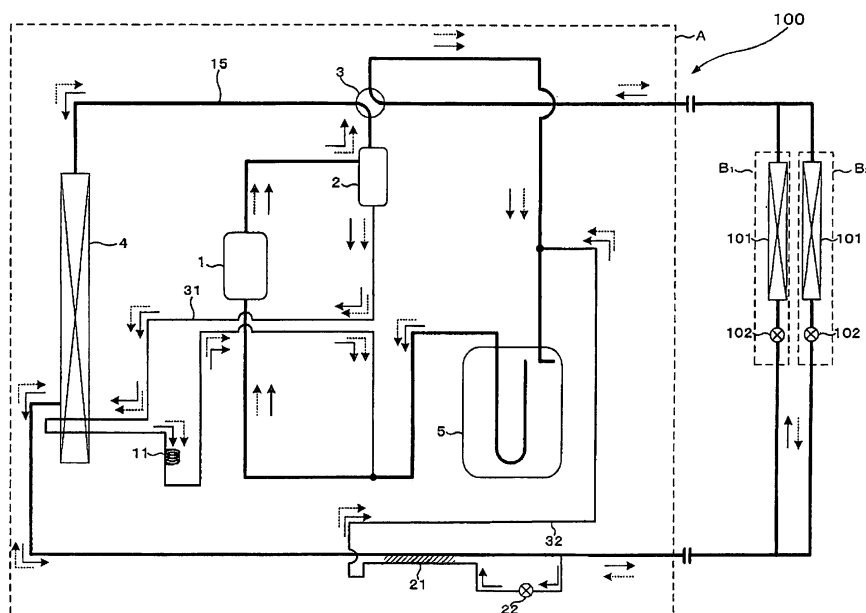
(54) **AIR CONDITIONER AND METHOD OF RETURNING REFRIGERATING MACHINE OIL**

(57) An air-conditioner capable of suppressing increase in the suction temperature of a compressor is provided.

The air-conditioner 100 according to the present invention has a refrigerant circuit in which a compressor 1, an oil separator 2, a heat source side heat exchanger 4, a throttle device 102, and a use side heat exchanger

101 are connected in series, an oil returning circuit 31 that connects the oil separator 2 with the suction side of the compressor 1, and a decompression mechanism 11 provided in the oil return circuit 31. The oil return circuit 31 is installed by piping so as to exchange heat with a part of the heat source side heat exchanger 4 at the upstream side of the decompression mechanism 11.

FIG. 1



Description

Technical Field

[0001] The present invention relates to an air-conditioner having a refrigerant circuit and a method of returning refrigerator oil discharged along with a refrigerant from a compressor constituting the refrigeration cycle thereof to the compressor.

Background Art

[0002] In an air-conditioner having a refrigerant circuit (refrigeration cycle) represented by a multi air-conditioner for buildings, in which a plurality of load-side indoor units is connected and each indoor unit is operated separately, refrigerator oil is discharged along with a refrigerant from a compressor. In such an air-conditioner, conventionally, an oil separator has been disposed in general at the secondary side (discharge side) of the compressor for the purpose of reducing the distribution amount of the refrigerator oil brought out of the compressor in the refrigeration circuit to immediately return to the compressor.

(Refer to Patent Document 1, for example)

[0003] Reasons for disposing the oil separator are given as follows. First, as a connecting pipe (refrigerant pipe) that links a heat source unit (outdoor unit) with an indoor unit becomes longer, the amount of refrigerator oil distributed in the connecting pipe increases and a necessary oil amount in the compressor possibly runs short. Second, since a plurality of indoor units separately start/stop, the refrigerator oil is sometimes accumulated in the suspended indoor unit. Third, when the refrigerant stagnates in the compressor and the compressor is started under the condition that oil is diluted, it takes time for the compound liquid of the brought-out refrigerant and refrigerator oil to return to the compressor after circulating in the refrigerant circuit, resulting in the lowering of reliability of the compressor possibly.

[0004] In the air-conditioner described in Patent Literature 1, the refrigerator oil brought out of the compressor is adapted to be separated into a high-pressure high-temperature gas refrigerant and refrigerator oil by an oil separator. Then, the high-pressure high-temperature gas refrigerant flows into a heat source side heat exchanger and the separated refrigerator oil is returned to the primary side (suction side) of the compressor under low-pressure low-temperature conditions after being decompressed by a decompression apparatus. At that time, part of the high-pressure high-temperature gas refrigerant is decompressed by the decompression apparatus along with the refrigerator oil and returned to the suction side of the compressor under the low-pressure high-temperature condition at the same time with the refrigerator oil.

[0005] Reasons for returning oil to the primary side of the compressor are given as follows. First, the refrigerator oil discharged from the compressor along with the refrigerant and brought out from the compressor needs to be returned to the compressor without delay. Second, the refrigerator oil discharged from the compressor along with the refrigerant and brought out from the compressor needs to be returned to the compressor before the concentration of the refrigerator oil in the compressor becomes extremely lowered.

Citation List

Patent Literature

[0006] Patent Literature 1 Japanese Patent No.3866359 (Embodiment 8, Fig. 9)

Summary of Invention

Technical Problem

[0007] In the related art air-conditioner described in Patent Literature 1, while a refrigerator oil brought out of the compressor used to be directly returned to a suction opening, which is the primary side of the refrigerator, for the purpose of securing the amount of the refrigerator oil in the compressor, there are problems as shown below. By directly returning the low-pressure high-temperature refrigerator oil and gas refrigerant to the suction opening of the compressor, a temperature increases and a refrigerant density is lowered at the suction opening of the compressor, and a refrigerant circulation amount of the compressor is lowered, resulting in deterioration of the performance of the compressor. That is, power consumption necessary to meet predetermined capacity of the compressor increases. Further, since the suction temperature of the compressor increase, the discharge temperature of the compressor is apt to increase as well, causing the temperature rise in a motor wiring to affect reliability of the compressor.

[0008] The present invention is made to solve the above problems, and a first object is to provide an air-conditioner and a method of returning refrigerator oil that enable to suppress the rise in the suction temperature of the compressor. In addition to the first object, a second object is to provide the air-conditioner and the method of returning the refrigerator oil whose performance is further improved by transferring the refrigerant flow amount bypassed to the suction side of the compressor to the refrigerant circulation amount to a load side.

Solution to Problem

[0009] An air-conditioner according to the present invention has a refrigerant circuit in which a compressor, an oil separator, a heat source side heat exchanger, a throttle device, and a use side heat exchanger are con-

nected in order, an oil return circuit that connects the oil separator with the suction side of the compressor, and a decompression mechanism provided in the oil return circuit. The oil return circuit is installed by piping so as to exchange heat with at least part of the heat source side heat exchanger at the upper stream side of the decompression mechanism.

[0010] A method of returning refrigerator oil according to the present invention is a method of refrigerator oil used in the above air-conditioner. The refrigerator oil separated by the oil separator is led to a portion of the heat source side heat exchanger along with part of the remaining refrigerant without being separated by the oil separator and, after releasing heat, is returned to the suction side of the compressor.

Advantageous Effects of Invention

[0011] In accordance with the air-conditioner and the method of returning oil according to the present invention, since the high-pressure high-temperature gas refrigerant and the refrigerator oil separated by the oil separator are led to a portion of the heat source side heat exchanger, and are returned to the compressor after being made to release heat, an increase of a compressor suction temperature can be suppressed and performance can be improved. By suppressing the increase of the compressor suction temperature, an increase of a compressor discharge temperature can be suppressed as well, enabling to contribute to the improvement of reliability of the compressor such as suppressing an increase of a motor wiring temperature.

Brief Description of Drawings

[0012]

[Fig. 1]

Fig. 1 is a refrigerant circuit diagram showing a refrigerant circuit configuration of an air-conditioner according to Embodiment 1.

[Fig. 2]

Fig. 2 is an illustrative diagram showing an example of the wind speed distribution on a surface of the heat source side heat exchanger.

[Fig. 3]

Fig. 3 is a refrigerant circuit diagram showing a refrigerant circuit configuration of an air-conditioner according to Embodiment 2.

[Fig. 4]

Fig. 4 is a refrigerant circuit diagram showing a refrigerant circuit configuration of an air-conditioner according to Embodiment 3.

[Fig. 5]

Fig. 5 is a Mollier diagram showing transitions of a refrigerant at the time of a cooling and a heating operation of the air-conditioner.

Description of Embodiments

[0013] Descriptions will be given to embodiments of the present invention based on drawings.

Embodiment 1

[0014] Fig. 1 is a refrigerant circuit diagram showing a refrigerant circuit configuration of an air-conditioner 100 according to Embodiment of the present invention. Based on Fig. 1, descriptions will be given to the refrigerant circuit configuration and operations of the air-conditioner 100, which is a refrigeration cycle apparatus. The air-conditioner 100 performs a cooling operation or a heating operation using a refrigeration cycle (heat pump cycle) that makes the refrigerant circulate. In Fig. 1, solid line arrows denote the refrigeration circuit at the time of the cooling operation and dotted line arrows denote the refrigeration circuit at the time of the heating operation, respectively. In some case, in the drawings below including Fig. 1, relations of sizes of each constituting member may be different from actual ones.

[0015] As shown in Fig. 1, the air-conditioner 100 is constituted by an outdoor unit (heat source unit) A and two indoor units (indoor unit B₁ and indoor unit B₂) connected in parallel with the outdoor unit A. The outdoor unit A and the indoor unit B are connected with a refrigerant pipeline 15 constituted by a gas pipeline and a liquid pipeline. Consequently, the air-conditioner 100 configures a refrigerant circuit by the outdoor unit A and the indoor unit B. A cooling operation and a heating operation are possible to be realized by making a refrigerant circulate in the refrigerant circuit. In the descriptions as follows, the indoor unit B₁ and indoor unit B₂ are combined and referred to as an indoor unit B in some case. The number of the outdoor unit A and the indoor unit B, which are connected, is not limited to the number shown in the drawings.

Outdoor unit A

[0016] The outdoor unit A has a function to feed cooling energy to the indoor unit B. In the outdoor unit A, the compressor 1, an oil separator 2, a four-way valve 3, a heat source side heat exchanger 4, a refrigerant - refrigerant heat exchanger 21, and an accumulator 5 are provided so as to be connected in series at the time of the cooling operation. In the outdoor unit A, an oil returning circuit 31 is provided that connects the oil separator 2 with the suction side of the compressor 1 via the heat source side heat exchanger 4 and the decompression mechanism 11. Further, in the outdoor unit A, a bypass circuit 32 is provided that connects the downstream side (condensation side) of the refrigerant-refrigerant heat exchanger 21 at the time of the cooling operation with the upstream side of the accumulator 5 via the super-cooling expansion valve 22 and the evaporation side of the refrigerant-refrigerant heat exchanger 21.

[0017] The first compressor 1 sucks and compresses the refrigerant to turn it into a high-pressure high-temperature state and may be configured by a capacity-controllable inverter compressor, for example. The oil separator 2 is provided at the discharge side of the compressor 1 to separate a refrigerator oil component from a refrigerant gas discharged from the compressor 1 and mixed with refrigerator oil. The four-way valve 3 functions as a flow path switching device that switches refrigerant flows and switches the refrigerant flow at the time of the cooling operation and the refrigerant flow at the time of the heating operation. The heat source side heat exchanger 4 functions as a condenser (a radiator) at the time of the cooling operation and as an evaporator at the time of the heating operation and exchanges heat between the air supplied from a blower such as a fan, which is not shown, and the refrigerant so as to condense-liquefy (or turns it into a high-density super-critical state) or evaporate-gasify the refrigerant.

[0018] The refrigerant-refrigerant heat exchanger 21 exchange heat between the refrigerant flowing through the refrigerant pipeline 15 and the refrigerant flowing through the bypass circuit 32. The accumulator 5 is provided at the primary side (suction side) of the compressor 1 to store a surplus refrigerant. The oil returning circuit 31 returns the refrigerator oil and part of refrigerant separated by the oil separator 2 to the suction side of the compressor 1 via a part (here, a part where the wind speed distribution of the heat source side heat exchanger 4 is the minimum (refer to Fig. 2)) of the heat source side heat exchanger 4 and the decompression mechanism 11. The decompression mechanism 11 is provided at the downstream side of the heat source side heat exchanger 4 in the oil returning circuit 31 to decompress the refrigerant flowing through the oil returning circuit 31. The decompression mechanism 11 may be configured by those whose opening degree is variably controllable, for example, an electronic expansion valve and a capillary and the like.

[0019] The bypass circuit 32 bypasses part of the refrigerant super-cooled in the refrigerant-refrigerant heat exchanger 21 to the upstream side of the accumulator 5 via the super-cooling expansion valve 22 and the refrigerant-refrigerant heat exchanger 21. The super-cooling expansion valve 22 is provided at the upstream side (evaporation side) of the refrigerant-refrigerant heat exchanger 21 of the bypass circuit 32 at the time of the cooling operation to decompress and expand the refrigerant flowing through the bypass circuit 32. The super-cooling expansion valve 22 may be configured by those whose opening degree is variably controllable, for example, an electronic expansion valve and the like.

Indoor unit B

[0020] The indoor unit B is disposed in a room having an area to be air-conditioned or the like and has a function to supply air for cooling or heating to the area to be air-

conditioned. In the indoor unit B, a use side heat exchanger 101 and a throttle device 102 are connected in series and disposed. The use side heat exchanger 101 functions as an evaporator at the time of the cooling operation and as a condenser (a radiator) at the time of the heating operation to exchange heat between the air supplied by a blower such as a fan, which is not shown, and the refrigerant and prepares heating air or cooling air for supplying the same to the area to be air-conditioned. The throttle device 102 decompresses and expands the refrigerant to adjust the refrigerant distribution to the use side heat exchanger 101. The throttle device 102 may be configured by an electronic expansion valve and the like whose opening degree is variable.

[0021] Descriptions will be given to the refrigerant flow at the time of various operations of the air-conditioner 100.

When the air-conditioner 100 performs cooling operation (solid line arrows), the four-way valve 3 is switched so that the refrigerant discharged from the compressor 1 flows into the heat source side heat exchanger 4 and the compressor 1 is driven. The refrigerant sucked by the compressor 1 turns into a high-pressure high-temperature gas state in the compressor 1 and is discharged to flow into the heat source side heat exchanger 4 via the oil separator 2 and the four-way valve 3. The refrigerant flowed into the heat source side heat exchanger 4 is cooled while releasing heat into the air supplied from the blower, which is not shown, and turns into a low-pressure high-temperature liquid refrigerant to flow out from the heat source side heat exchanger 4.

[0022] The liquid refrigerant flowing out from the heat source side heat exchanger 4 flows into the indoor unit B. The refrigerant flowed into the indoor unit B is decompressed by the throttle device 102 to turn into a low-pressure two-phase refrigerant. The low-pressure two-phase refrigerant flows into the use side heat exchanger 101 to evaporate and gasify by absorbing heat supplied by the air from a blower, which is not shown. Then, cooling air is supplied into the space to be air-conditioned such as inside of the room and cooling operation in the space to be air-conditioned is achieved. The refrigerant flowed out from the use side heat exchanger 101 flows out of the indoor unit B, flows into the outdoor unit A, passes through the four-way valve 3 and the accumulator 5 of the outdoor unit A, and absorbed by the compressor 1 again.

[0023] When the air-conditioner 100 performs a heating operation (broken line arrows), the four-way valve 3 is switched so that the refrigerant discharged from the compressor 1 flows into the use side heat exchanger 101 and the compressor 1 is driven. The refrigerant sucked by the compressor 1 turns into a high-pressure high-temperature gas state in the compressor 1 and is discharged to flow into the use side heat exchanger 101 via the oil separator 2 and the four-way valve 3. The refrigerant flowed into the heat source side heat exchanger 101 is cooled while releasing heat into the air supplied from a

blower, which is not shown, to turn into a low-pressure high-temperature liquid refrigerant. Then, heating air is supplied into the space to be air-conditioned such as inside of the room and heating operation in the space to be air-conditioned is achieved.

[0024] The liquid refrigerant flowed out of the use side heat exchanger 101 is decompressed by the throttle device 102 to turn into a low-pressure two-phase refrigerant. The low-pressure two-phase refrigerant flows out of the indoor unit B to flow into the outdoor unit A. The low-pressure two-phase refrigerant flowed into the outdoor unit A flows into the heat source side heat exchanger 4 to evaporate and gasify by absorbing heat from the air supplied by the blower, which is not shown. The low-pressure gas refrigerant flows out of the heat source side heat exchanger 4 and passes through the four-way valve 3 and the accumulator 5 to be sucked by the compressor 1 again.

[0025] Incidentally, the refrigerator oil brought out of the compressor 1 along with the refrigerant flows into the oil separator 2 and is separated from the high-pressure gas refrigerant in the oil separator 2. However, in the oil separator 2, the high-pressure gas refrigerant and the refrigerator oil are not always separated completely (100 %). The oil separator 2 can separate almost 90 % of the refrigerator oil, for example. The remaining almost 10 % of the refrigerator oil is not separated and circulates in the refrigerant circuit with the refrigerant. In the oil separator 2, the high-pressure high-temperature gas refrigerant does not always flow into the refrigerant circuit completely, as well. The oil separator 2 can separate approximately 97 to 98 % of refrigerant, for example. The remaining approximately 2 to 3 % of the high-pressure high-temperature gas refrigerant is adapted to be finally returned to the compressor 1 with the refrigerator oil.

[0026] Part of the high-pressure high-temperature gas refrigerant and the refrigerator oil separated in the oil separator 2 flows into a portion of the heat source side heat exchanger 4 through the oil returning circuit 31 to the compressor 1. In Fig. 1, the oil returning circuit 31 may pass through the portion of the heat source side heat exchanger 4 that is, for example, a part where the wind speed distribution on the surface of the heat exchanger is the smallest (a part having poor contribution as heat exchange amount). The high-pressure high-temperature gas refrigerant flowed into the portion of the heat source side heat exchanger 4 turns into a high-pressure medium-temperature liquid state by releasing heat in the heat source side heat exchanger 4 to flow into the decompression mechanism 11. In the decompression mechanism 11, the high-pressure medium-temperature liquid refrigerant is decompressed to be low-pressure low-temperature and returned to the suction side of the compressor 1 with the refrigerator oil.

[0027] Fig. 2 is an illustrative diagram showing an example of the wind speed distribution on a surface of the heat source side heat exchanger 4. Based on Fig. 2, descriptions will be given to the oil returning circuit 31 which

is connected with the heat source side heat exchanger 4 along with the wind speed distribution on the surface of the heat source side heat exchanger 4. Fig. 2 illustrates the fan 50 as well. As mentioned above, the refrigerant and the refrigerator oil each flowing through the oil returning circuit 31 are adapted to flow through the portion of the heat source side heat exchanger 4. When the outdoor unit A has a configuration such that outdoor air is sucked from a side face and blown out to upward through the heat source side heat exchanger 4, a wind speed distribution shown in Fig. 2 is generated on the surface of the heat source side heat exchanger 4.

[0028] That is, in the heat source side heat exchanger 4 like this, the wind speed distribution becomes small from the upper section near the fan 50 to the lower section away from the fan 50. Because of the wind speed distribution like this, in the lower section where the wind speed distribution is small, contribution rate to the entire radiation amount of the heat source side heat exchanger 4 becomes small. However, the radiation amount is enough to radiate small amount of the high-pressure high-temperature gas refrigerant, which is a part separated in the oil separator 2. Consequently, the air-conditioner 100 makes the refrigerant and the refrigerator oil flow through the oil returning circuit 31 and exchange heat in a portion where the wind speed distribution of the heat source side heat exchanger 4 is the smallest. For example, when the fan 50 is provided at the upper part as shown in Fig. 2, the refrigerant and the refrigerator oil flowing through the oil returning circuit 31 may be made to exchange heat at a portion of from the intermediate position in a height direction to the lower side of the heat source side heat exchanger 4.

[0029] As mentioned above, the air-conditioner 100 is adapted to make part of the high-pressure high-temperature gas refrigerant and the refrigerator oil separated by the oil separator 2 release heat in the heat source side heat exchanger 4, then to return it to the compressor 1. Thereby, compared with a conventional air-conditioner where the high-pressure high-temperature gas refrigerant and the refrigerator oil are directly returned to the compressor suction side, enthalpy at the compressor suction side is reduced and refrigerant density at the compressor suction side increases. Accordingly, it is possible to suppress temperature rise at the compressor suction side. Further, since the gas refrigerant density sucked into the compressor 1 increases and the refrigerant circulation amount in the refrigeration circuit increases, the performance of the air-conditioner 100 is improved. The rise in the discharge temperature of the compressor 1 can be suppressed by suppressing the rise in the suction temperature, which contributes to the improvement of the reliability of the compressor 1 such as suppression of the rise in the motor wiring temperature.

Embodiment 2

[0030] Fig. 3 is a refrigerant circuit diagram showing a

refrigerant circuit configuration of an air-conditioner 100a according to Embodiment 2. Based on Fig. 3, descriptions will be given to the refrigerant circuit configuration and operations of the air-conditioner 100a, which is one of refrigeration cycle apparatuses. The air-conditioner 100a performs a cooling operation or a heating operation using a refrigeration cycle that makes the refrigerant circulate. In Fig. 3, solid line arrows denote the refrigeration circuit at the time of the cooling operation and dotted line arrows denote the refrigeration circuit at the time of the heating operation, respectively. In Embodiment 2, the same signs are given to the same portions as Embodiment 1 and descriptions will be given focusing on differences from Embodiment 1.

[0031] In Embodiment 1, while descriptions are given to the air-conditioner 100, in which part of the high-pressure high-temperature gas refrigerant and the refrigerator oil separated by the oil separator 2 are adapted to be returned to the compressor 1 after being made to release heat in the heat source side heat exchanger 4, in Embodiment 2, descriptions will be given to the air-conditioner 100a, in which radiation effect is further improved. As shown in Fig. 3, although the basic refrigerant circuit configuration of the air-conditioner 100a is the same as the air-conditioner 100 according to Embodiment 1, the air-conditioner 100a is different from the air-conditioner 100 according to Embodiment 1 in that a super-cooling heat exchanger 12 is provided in the oil returning circuit (hereinafter, referred to as an oil returning circuit 31a).

[0032] The super-cooling heat exchanger 12 is provided between the heat source side heat exchanger 4 of the oil returning circuit 31a and the decompression mechanism 11 to exchange heat between part of the refrigerant separated in the oil separator 2 and made to release heat in the heat source side heat exchanger 4 and the refrigerant flowed out of the heat source side heat exchanger 4 and decompressed by the decompression mechanism 11. Consequently, in the air-conditioner 100a, part of the high-pressure high-temperature gas refrigerant and the refrigerator oil separated by the oil separator 2 can be made to further release heat in the super-cooling heat exchanger 12 after being made to release heat in the heat source side heat exchanger 4. As explained in Embodiment 1, the oil returning circuit 31a may install pipelines so as to exchange heat at a section where the wind speed distribution of the heat source side heat exchanger 4 is the smallest.

[0033] Descriptions will be given to the flow of the refrigerant and refrigerator oil in the oil returning circuit 31a of the air-conditioner 100a. The refrigerant flow at the time of various operations of the air-conditioner 100a is the same as that of the air-conditioner 100 according to Embodiment 1. The refrigerator oil brought out of the compressor 1 along with the refrigerant flows into the oil separator 2 and is separated from the high-pressure gas refrigerant in the oil separator 2. Part of the high-pressure high-temperature gas refrigerant and the refrigerator oil separated in the oil separator 2 flows into the portion of

the heat source side heat exchanger 4 through the oil returning circuit 31a to the compressor 1. The high-pressure high-temperature gas refrigerant flowed into the portion of the heat source side heat exchanger 4 turns into a high-pressure medium-temperature liquid refrigerant by releasing heat in the heat source side heat exchanger 4.

[0034] The high-pressure medium-temperature liquid refrigerant and the refrigerator oil flowing out of the heat source side heat exchanger 4 flows into the condensation side of the super-cooling heat exchanger 12. In the super-cooling heat exchanger 12, the high-pressure medium-temperature liquid refrigerant and the refrigerator oil exchange heat with the low-pressure two-phase refrigerant and the refrigerator oil flowed into the evaporation side of the super-cooling heat exchanger 12 through the decompression mechanism 11 and turns into a super-cooled high-pressure medium-temperature liquid refrigerant and the refrigerator oil to flow into the decompression device. In the decompression mechanism 11, the high-pressure medium-temperature liquid refrigerant is decompressed to be a low-pressure low-temperature two-phase refrigerant and flows into the evaporation side of the super-cooling heat exchanger 12 along with the refrigerator oil. The low-pressure low-temperature two-phase refrigerant exchanges heat with the refrigerant and the refrigerator oil flowed into the condensation side of the super-cooling heat exchanger 12 and turns into a low-pressure low-temperature gas refrigerant to be returned into the suction side of the compressor 1 with the refrigerator oil.

[0035] As mentioned above, the air-conditioner 100 is adapted to make part of the high-pressure high-temperature gas refrigerant and the refrigerator oil separated by the oil separator 2 release heat in the heat source side heat exchanger 4, then return them to the compressor 1 after super-cooling in the super-cooling heat exchanger 12. Thereby, compared with a conventional air-conditioner where the high-pressure high-temperature gas refrigerant and the refrigerator oil are directly returned to the suction side of the compressor, enthalpy at the compressor suction side is reduced and refrigerant density at the compressor suction side increases. Accordingly, it is possible to suppress temperature rise at the suction side of the compressor.

[0036] Since the density of the gas refrigerant sucked into the compressor 1 increases and the refrigerant circulation amount increases, the performance of the air-conditioner 100a is improved. The rise in the discharge temperature of the compressor 1 can be suppressed by suppressing the rise in the suction temperature, which contributes to the improvement of the reliability of the compressor 1 such as suppression of the rise in the motor wiring temperature. In addition, in the air-conditioner 100a, since not the refrigerant under a low-pressure low-temperature two-phase state returns to the compressor 1 but a low-pressure gas refrigerant returns to the compressor 1, a liquid back ratio can be reduced as a liquid

back amount against the refrigerant circulation amount of the compressor 1. Accordingly, it is possible to suppress dilution of the oil concentration in the compressor 1 and to improve reliability of the air-conditioner 100a further.

Embodiment 3

[0037] Fig. 4 is a refrigerant circuit diagram showing a refrigerant circuit configuration of an air-conditioner 100b according to Embodiment 3 of the present invention. Based on Fig. 4, descriptions will be given to the refrigerant circuit configuration and operations of the air-conditioner 100b, which is one of refrigeration cycle apparatuses. The air-conditioner 100b performs a cooling operation or a heating operation using a refrigeration cycle that makes the refrigerant circulate. In Fig. 4, solid line arrows denote the refrigeration circuit at the time of the cooling operation and dotted line arrows denote the refrigeration circuit at the time of the heating operation, respectively. In Embodiment 3, the same signs are given to the same portions as Embodiments 1 and 2, and descriptions will be given focusing on differences from Embodiments 1 and 2.

[0038] Descriptions are given to an air-conditioner, in which while in Embodiment 1 part of the high-pressure high-temperature gas refrigerant and the refrigerant oil separated by the oil separator 2 are adapted to be returned to the compressor 1 after being made to release heat in the heat source side heat exchanger 4, and in Embodiment 2, part of the high-pressure high-temperature gas refrigerant and the refrigerant oil separated by the oil separator 2 are adapted to be returned to the compressor 1 after being made to release heat in the heat source side heat exchanger 4 and super-cooling heat exchanger 12, respectively. In Embodiment 3, descriptions will be given to the air-conditioner 100b, which is configured to further enhance performance improvement effect. As shown in Fig. 4, although the basic refrigerant circuit configuration of the air-conditioner 100b is the same as the air-conditioner 100 according to Embodiment 1 and the air-conditioner 100a according to Embodiment 2, the oil returning circuit (hereinafter, referred to as an oil returning circuit 31b) is different.

[0039] The oil returning circuit 31b leads the refrigerant oil and part of the refrigerant separated by the oil separator 2 through the portion of the heat source side heat exchanger 4 and the decompression mechanism 11 to the evaporation side inlet of the refrigerant - refrigerant heat exchanger 21, which is in between the refrigerant - refrigerant heat exchanger 21 and super-cooling expansion valve 22 of the bypass circuit 32. That is, in the air-conditioner 100b, the oil returning circuit 31b does not return the low-pressure low-temperature two-phase refrigerant and the refrigerant oil decompressed by the decompression mechanism 11 to the suction side of the compressor 1, but passes to join at the evaporation side inlet of the refrigerant-refrigerant heat exchanger 21. In

addition, as explained in Embodiment 1, the oil returning circuit 31b may be installed by piping so as to exchange heat at a section where the wind speed distribution of the heat source side heat exchanger 4 is the smallest.

[0040] Fig. 5 is a Mollier diagram (a diagram showing the relation between the pressure of the refrigerant and enthalpy) showing transitions of the refrigerant at the time of the cooling operation of the air-conditioner 100b. Based on Figs. 4 and 5, descriptions will be given to the refrigerant flow at the time of the cooling operation of the air-conditioner 100b. The refrigerant states at points "A" to "F" shown in Fig. 5 correspond to the refrigerant status at points "A" to "F" shown in Fig. 4. In Fig. 5, the vertical axis denotes pressure [MPa] and the horizontal axis denotes enthalpy [kJ/kg], respectively. In addition, as for the refrigerant flow at the time of the heating operation of the air-conditioner 100b is the same as that of the air-conditioner 100 according to Embodiment 1.

[0041] When the air-conditioner 100b performs the cooling operation (solid line arrows), the four-way valve 3 is switched so that the refrigerant discharged from the compressor 1 flows into the heat source side heat exchanger 4 and the compressor 1 is driven. The refrigerant sucked by the compressor 1 turns into a high-pressure high-temperature gas state in the compressor 1 and is discharged (status "A") to flow into the heat source side heat exchanger 4 via the oil separator 2 and the four-way valve 3. The refrigerant flowed into the heat source side heat exchanger 4 is cooled while releasing heat to the air supplied from the fan not shown and turns into a low-pressure high-temperature liquid refrigerant to flow out from the heat source side heat exchanger 4 (status "B").

[0042] The liquid refrigerant flowed out of the heat source side heat exchanger 4 flows into the condensation side of the refrigerant-refrigerant heat exchanger 21. The refrigerant flowed into the refrigerant-refrigerant heat exchanger 21 exchanges heat with the low-pressure two-phase refrigerant flowing through the evaporation side of the refrigerant-refrigerant heat exchanger 21 and is subjected to super-cooling (status "C"). Part of the high-pressure liquid refrigerant flowed out of the refrigerant-refrigerant heat exchanger 21 and subjected to super-cooling flows out from the indoor unit A to flow into the indoor unit B. The refrigerant flowed into the indoor unit B is decompressed by the throttle device 102 to turn into a low-pressure two-phase refrigerant (status "D").

[0043] On the other hand, part of the high-pressure liquid refrigerant flowed out of the refrigerant-refrigerant heat exchanger 21 and subjected to super-cooling flows into the bypass circuit 32. The liquid refrigerant flowed into the bypass circuit 32 is decompressed by the super-cooling expansion valve 22 to turn into a low-pressure two-phase refrigerant. The refrigerant turned into the low-pressure two-phase refrigerant in the super-cooling expansion valve 22 flows into the evaporation side of the refrigerant-refrigerant heat exchanger 21 and exchanges heat with the high-pressure liquid refrigerant at the condensation side of the refrigerant-refrigerant heat ex-

changer 21 to turn into a low-pressure gas refrigerant (status "E"). The low-pressure gas refrigerant flowed out of the evaporation side of the refrigerant-refrigerant heat exchanger 21 is led between the four-way valve 3 and the accumulator 5 and flows into the accumulator 5 to finally return to the compressor 1.

[0044] Thereby, when the high-pressure liquid refrigerant flowing into the throttle device 102 at the indoor unit B side is subjected to super-cooling, enthalpy decreases and in the case where capacity is constant, the refrigerant flow amount into the indoor unit B can be reduced by the amount corresponding to the reduction of enthalpy. That is, since it is expressed that capacity $Q = \text{refrigerant flow amount } Gr \times \text{difference enthalpy } \Delta I$ at the inlet/outlet of the evaporator (use side heat exchanger 101), enthalpy decreases by making the high-pressure liquid refrigerant subjected to super-cooling, allowing the refrigerant flow amount Gr to be small (Gr') by the amount ($\Delta I'$) corresponding to the amount by which difference enthalpy ΔI could be made large.

[0045] in the case of cooling, since a pressure loss in the use side heat exchanger 101 at the load side and a pressure loss in the low-pressure line from the outlet of the use side heat exchanger 101 to the suction of the compressor are decreased (status "E" to "F") by the amount by which the refrigerant flow amount to the indoor unit B can be reduced, the suction pressure of the compressor 1 can be increased. Accordingly, since the suction pressure of the compressor 1 can be increased, the refrigerant flow amount of the compressor 1 itself increases to enhance the capacity of the compressor 1. Since the operation frequency in proportion to the push-aside amount of the compressor 1 can be reduced as much as the increased capacity of the compressor 1, power consumption is decreased and performance is improved resultantly.

[0046] Descriptions will be given to the refrigerant flow in the oil returning circuit 31b of the air-conditioner 100b. The refrigerator oil brought out of the compressor 1 along with the refrigerant flows into the oil separator 2 and separated from the high-pressure gas refrigerant in the oil separator 2. Part of the high-pressure high-temperature gas refrigerant and the refrigerator oil separated in the oil separator 2 flows into the portion of the heat source side heat exchanger 4 through the oil returning circuit 31b to the compressor 1. The high-pressure high-temperature gas refrigerant flowed into the portion of the heat source side heat exchanger 4 turns into a high-pressure medium-temperature liquid refrigerant by releasing heat in the heat source side heat exchanger 4.

[0047] The high-pressure medium-temperature liquid refrigerant flowed out of the heat source side heat exchanger 4 turns into a low-pressure low-temperature two-phase refrigerant in the decompression mechanism 11 and merges with the low-pressure two-phase refrigerant flowing through the bypass circuit 32 via the super-cooling expansion valve 22 to flow into the evaporation side of the refrigerant-refrigerant heat exchanger 21. The low-

pressure two-phase exchanges heat with the refrigerant flowing through the condensation side of the refrigerant-refrigerant heat exchanger 21, turns into a low-pressure low-temperature gas refrigerant, being guided between the four-way valve 3 and the accumulator 5 along with the refrigerator oil, and flows into the accumulator 5 to finally return to the compressor 1.

[0048] As mentioned above, the air-conditioner 100b makes part of the high-pressure high-temperature gas refrigerant and the refrigerator oil separated by the oil separator 2 release heat in the heat source side heat exchanger 4, merge into the high-pressure medium-temperature liquid refrigerant transferred to the indoor unit B at the evaporation side inlet of the refrigerant-refrigerant heat exchanger 21 in order to subject to super-cooling in the refrigerant-refrigerant heat exchanger 21, and then return to the compressor 1. Thereby, compared with a conventional air-conditioner where the high-pressure high-temperature gas refrigerant and the refrigerator oil are directly returned to the compressor suction side, the refrigerant flow amount to the evaporation side of the refrigerant-refrigerant heat exchanger 21 increases.

[0049] Consequently, if the difference enthalpy ΔI that satisfies a predetermined capacity Q is constant, the bypass flow amount from the super-cooling expansion valve 22 can be reduced by the amount of increase in the refrigerant flow amount to the evaporation side of the refrigerant-refrigerant heat exchanger 21. Therefore, the refrigerant flow amount to the indoor unit B increases by the reduction. When the refrigerant flow amount to the indoor unit B increases, capacity is enhanced. Therefore, the operation capacity (operation frequency in proportion to the push-aside amount of the compressor 1) of the compressor 1 can be reduced by the amount of the enhanced capacity, power consumption is decreased and performance is improved resultantly.

[0050] For example, when the refrigerant flow amount G_{b1} made to bypass by the oil separator 2 is 5 % and the bypass refrigerant flow amount G_{b2} to the evaporation side of the refrigerant-refrigerant heat exchanger 21 is 15 % against the entire refrigerant flow amount G discharged from the compressor 1, the refrigerant flow among Gr having flowed into the indoor unit B becomes $Gr = G - G_{b1} - G_{b2} = 100 \% - 5 \% - 15 \% = 80 \%$. If the refrigerant flow amount G_{b1} made to bypass by the oil separator 2 is made to join the bypass refrigerant flow amount G_{b2} to the evaporation side of the refrigerant-refrigerant heat exchanger 21 in place of directly being returned to the suction side of the compressor, the flow amount will be $G_{b2} = 5 \% + 15 \% = 20 \%$, resulting in an excess of 5 % from $G_{b2} = 15 \%$, which is originally required.

[0051] Therefore, by reducing the refrigerant flow amount from the super-cooling expansion valve 22 by 5 % to make it be 10 %, that is the original value, $G_{b2} = 5 \% + (15 - 5 \%)$ can be achieved, allowing the excess amount 5 % to flow into the indoor unit B. That is, the excess amount 5 % flows as the refrigerant amount Gr

to the indoor unit B, resulting in the increase in the refrigerant amount Gr flowing into the indoor unit B up to 85 %. The operation capacity of the compressor 1 can be reduced by the increased amount 5 % and power consumption is decreased, resulting in the improvement of performance.

[0052] Since the temperature rise in the suction side of the compressor is suppressed and the gas refrigerant density increases, the refrigerant circulation amount of the compressor 1 increases, which is a multiplier effect, allowing the performance of the air-conditioner 100b to be further improved. Moreover, the rise in the discharge temperature of the compressor 1 can be suppressed by suppressing the rise in the suction temperature, resulting in the contribution to the improvement of reliability of the compressor 1 such as control of the rise in the motor winding temperature. In addition, since no refrigerant flow amount bypassed by the oil separator 2 is directly returned to the compressor 1, the operation frequency in proportion to the push-aside amount of the compressor 1 can be reduced, allowing power consumption to be further decreased and performance to be improved resultantly.

Reference Signs List

[0053]

1	compressor	
2	oil separator	30
3	four-way valve	
4	heat source side heat exchanger	
5	accumulator	
11	decompression mechanism	
12	super-cooling heat exchanger	35
15	refrigerant pipeline	
21	refrigerant-refrigerant heat exchanger	
22	super-cooling expansion valve	
31, 31a, 31b	oil returning circuit	40
32	bypass circuit	
50	fan	
100, 100a, 100b	air-conditioner	
101	use side heat exchanger	
102	throttle device	45
A	outdoor unit	
B, B ₁ , B ₂	indoor unit	

Claims

1. An air-conditioner, comprising:

a refrigerant circuit, in which a compressor, an oil separator, a heat source side heat exchanger, a throttle device, and a use side heat exchanger are connected in order;
an oil return circuit that connects said oil separator with the suction side of said compressor;

and
a decompression mechanism provided in said oil return circuit, wherein

said oil return circuit is installed by piping so as to exchange heat with at least part of said heat source side heat exchanger at the upper stream side of said decompression mechanism.

2. The air-conditioner of claim 1, wherein a super-cooling heat exchanger in which a refrigerant and refrigerator oil flowing between said heat source side heat exchanger and said decompression mechanism exchanges heat with the refrigerant and refrigerator oil having passed through said decompression mechanism is provided in said oil returning circuit.

3. An air-conditioner comprising:

a refrigerant circuit, in which a compressor, an oil separator, a heat source side heat exchanger, a refrigerant - refrigerant heat exchanger, a throttle device, and a use side heat exchanger are connected in order;

a bypass circuit that connects between said refrigerant - refrigerant heat exchanger and said throttle device with the suction side of said compressor via said refrigerant - refrigerant heat exchanger;

a super-cooling expansion valve provided at the upstream side of said refrigerant - refrigerant heat exchanger in said bypass circuit;

an oil return circuit that connects said oil separator with said bypass circuit in between said super-cooling expansion valve and said refrigerant - refrigerant heat exchanger; and
a decompression mechanism provided in said oil return circuit, wherein

said oil return circuit is installed by piping so as to exchange heat with at least part of said heat source side heat exchanger at the upstream side of said decompression mechanism.

4. The air-conditioner according to any of claims 1 to 3 that provide for a fan, which supplies air to said heat source side heat exchanger, above said heat source side heat exchanger, wherein
said oil return circuit is installed by piping so as to exchange heat with a part of the lower side from the intermediate position in a height direction of said heat source side heat exchanger.

5. A method of returning refrigerator oil in the air-conditioner according to any of claims 1 to 3, wherein the refrigerator oil subjected to gas-oil separation by said oil separator is led to a part of said heat source side heat exchanger along with a part of the remain-

ing refrigerant without being gas-oil separated by said oil separator, and is returned to the suction side of said compressor after being made to release heat.

6. A method of returning refrigerator oil in the air-conditioner according to claim 1 or 2, wherein the refrigerator oil separated by said oil separator is led to a part of said heat source side heat exchanger along with a part of the remaining refrigerant without being separated by said oil separator, led to the condensation side of said super-cooling heat exchanger after being made to release heat, and returned to the suction side of said compressor after being made to exchange heat with the refrigerant flowing at the evaporation side of said super-cooling heat exchanger. 5 10 15
7. A method of returning refrigerator oil in the air-conditioner according to claim 3, wherein the refrigerator oil separated by said oil separator is led to a part of said heat source side heat exchanger along with a part of the remaining refrigerant without being separated by said oil separator, led to the evaporation side of said refrigerant-refrigerant heat exchanger after being made to release heat, and returned to the suction side of said compressor after being made to exchange heat with the refrigerant - refrigerant heat exchanger. 20 25 30

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FIG. 1

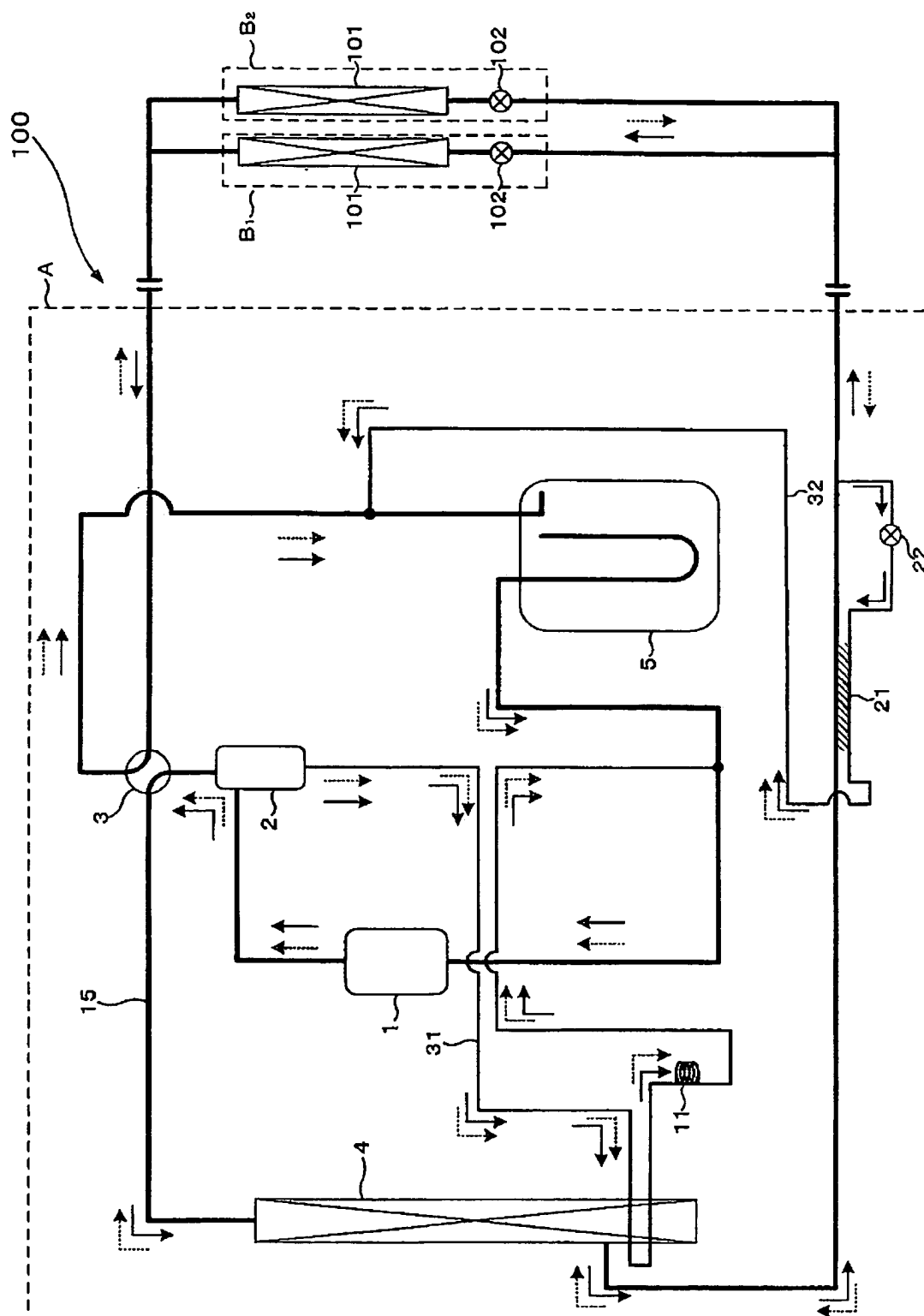


FIG. 2

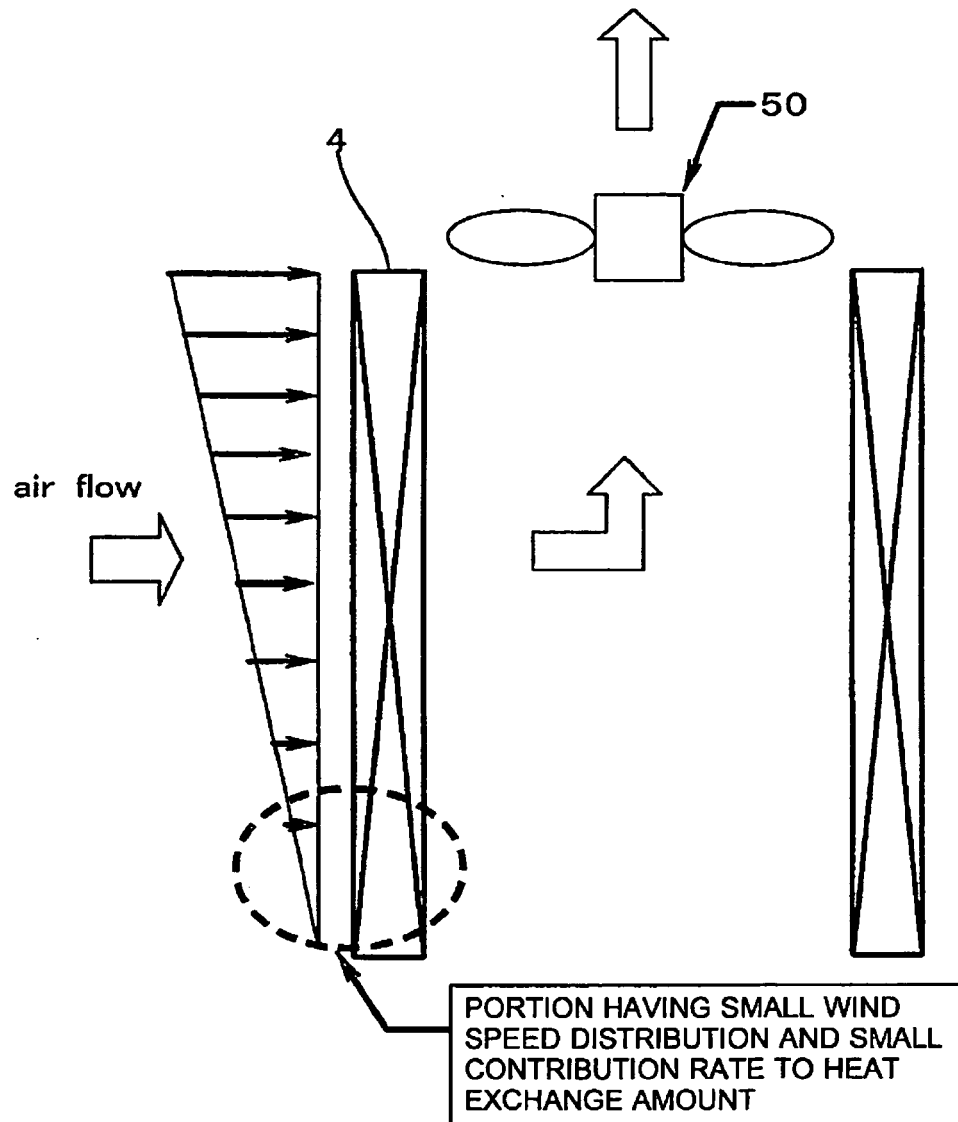


FIG. 3

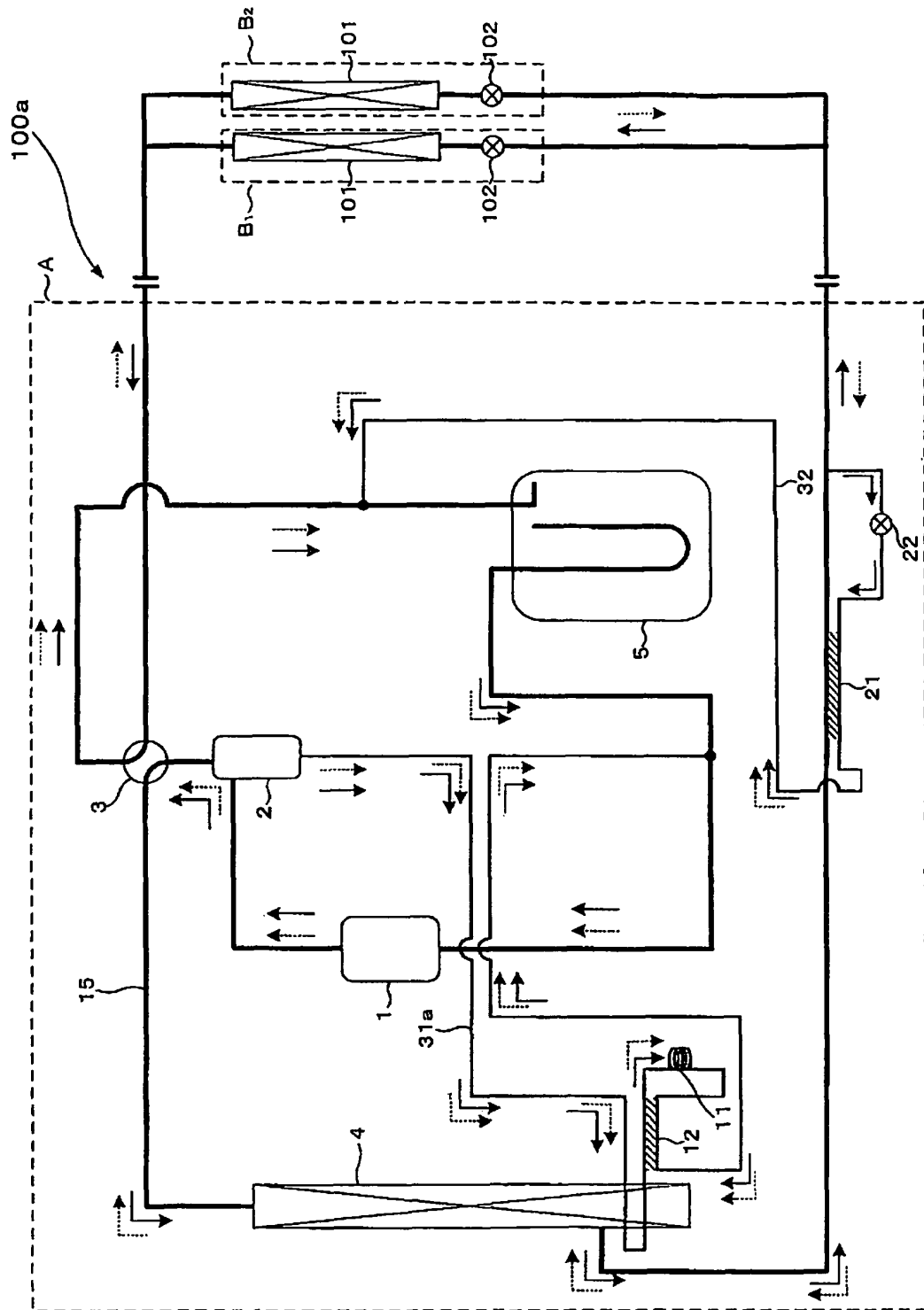


FIG. 4

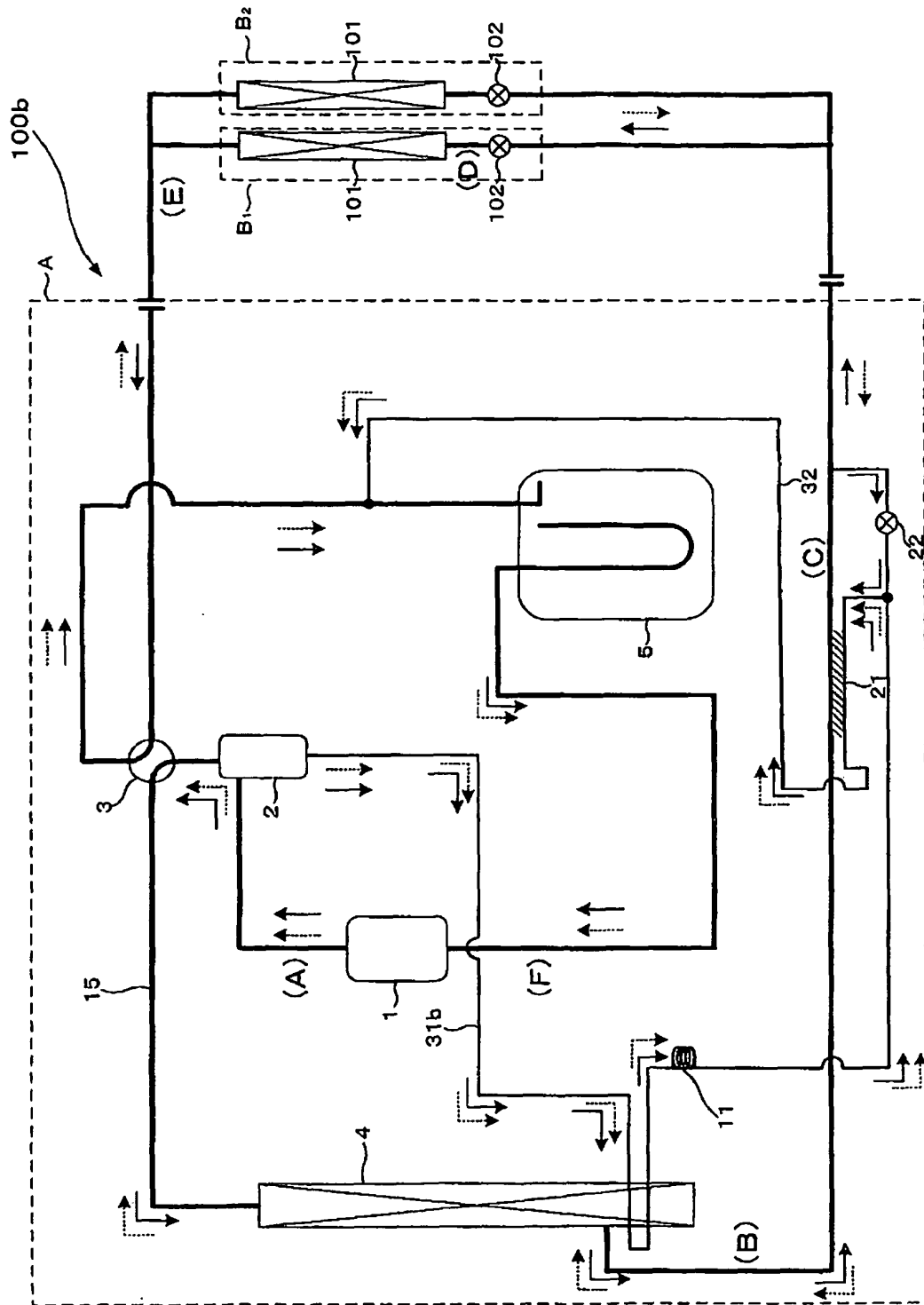
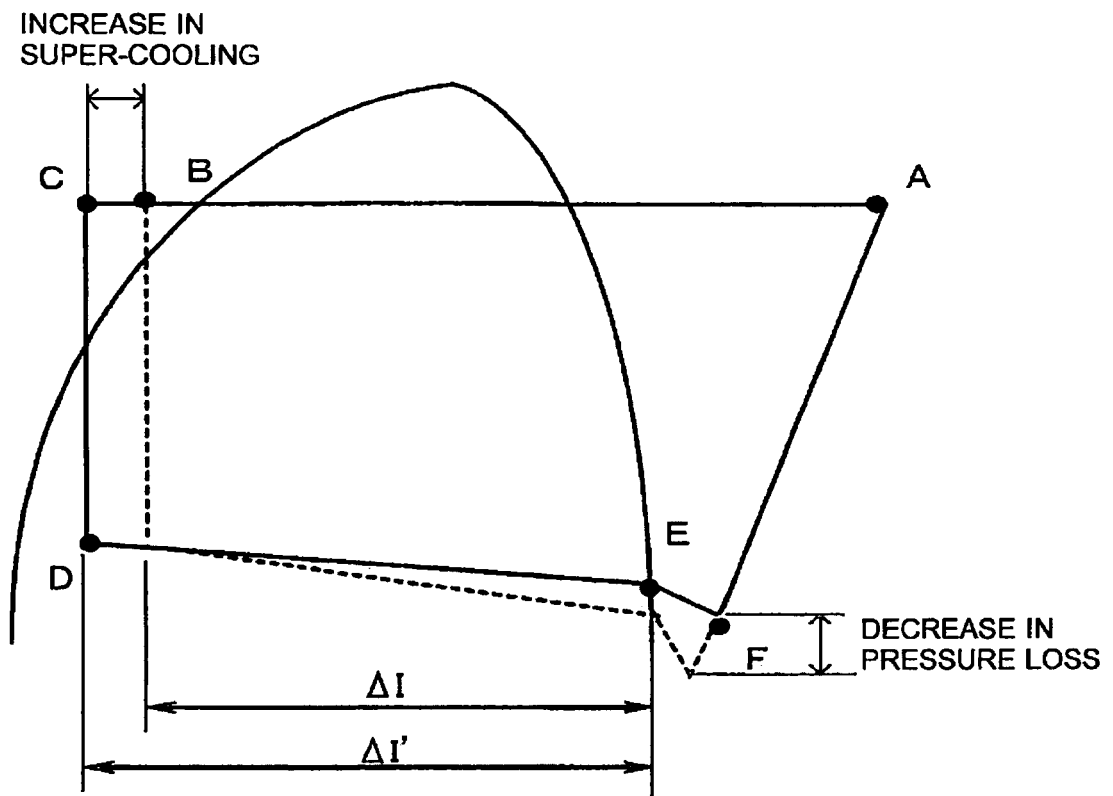


FIG. 5



$$Q = Gr \times \Delta I = Gr' \times \Delta I'$$

$$\begin{matrix} Gr > Gr' \\ \Delta I < \Delta I' \end{matrix}$$

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/051233

A. CLASSIFICATION OF SUBJECT MATTER F25B1/00 (2006.01) i		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) F25B1/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009 Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 6-337171 A (Mitsubishi Heavy Industries, Ltd.), 06 December, 1994 (06.12.94), Par. Nos. [0016] to [0026]; Figs. 1 to 2 (Family: none)	1 2, 4
X Y	JP 2002-206815 A (Daikin Industries, Ltd.), 26 July, 2002 (26.07.02), Par. Nos. [0025] to [0032]; Fig. 3 (Family: none)	1 2, 4
Y	JP 4-203764 A (Hitachi, Ltd.), 24 July, 1992 (24.07.92), Page 2, upper right column, line 7 to lower left column, line 7; Fig. 1 (Family: none)	2, 4
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 23 April, 2009 (23.04.09)		Date of mailing of the international search report 12 May, 2009 (12.05.09)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/051233

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The search revealed that the invention of claim 1 is described in document 1 (JP 6-337171 A) or document 2 (JP 2002-206815 A), and therefore the inventions of claims 1-7 have no special technical features which are the same or corresponding to each other. The requirement of unity of inventions is exceptionally not applied to the inventions of claims 2 and 4 because of Examination Guidelines (see "Examination Guidelines for Patent and Utility Model in Japan," Part I, Chapter 2, 4.2). Since the inventions of claims 5 and 6 which belong to a category different from that of claim 1 and the inventions of the claims citing claim 3 have no other common matter that can

(continued to extra sheet)

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1, 2, and 4

Remark on Protest
the

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/051233

Continuation of Box No.III of continuation of first sheet (2)

be considered as a special technical feature within the meaning of PCT Rule 13.2, second sentence, no technical relationship within the meaning of PCT Rule 13 between the different inventions can be seen.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 3866359 B [0006]